

WHAT IS CLAIMED IS:

1. A lens system comprising;

a plurality of lenses, a stop, and a diffractive surface,

5 said lens system moving the whole or part of the lens system during focusing and satisfying the following condition:

$$\beta \geq 0.5,$$

where β is a maximum photographic magnification.

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2. The lens system according to Claim 1, wherein part of the lens system moves during focusing, and said a plurality of lenses is arranged symmetric or substantially symmetric with respect to said stop.

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3. The lens system according to Claim 1, wherein said diffractive surface consists of a diffraction grating rotationally symmetric with respect to the optical axis,

20 wherein when the phase $\phi(h)$ of said diffraction grating is given by the following equation:

$$\phi(h) = 2\pi/\lambda*(C1*h^2 + C2*h^4 + C3*h^6 + \dots + Ci*h^{2i}),$$

25 where λ is an arbitrary wavelength in the visible region, Ci aspheric phase coefficients, and h a height from the optical axis,

the following conditions are satisfied:

$$C1 < 0 \text{ and } C2 > 0.$$

4. The lens system according to Claim 1, which satisfies the following condition:

$$|\Delta S/f| > 1.0,$$

5 where ΔS is a maximum moving distance of the whole of said lens system during focusing from an object at infinity to an object at a near distance, and f a focal length of the entire lens system.

10 5. A lens system comprising;
a diffractive surface, and
a first lens unit of a positive refracting power, a stop, and a second lens unit of a positive refracting power in the order (named) from the object side,
15 said lens system moves the whole of the lens system during focusing and changes air spaces before and after said stop during focusing.

6. The lens system according to Claim 5, which satisfies the following condition:

20 $0.7 < |\Delta s_1/\Delta s_2| < 1.3,$

where Δs_1 is a moving distance of said first lens unit during focusing and Δs_2 a moving distance of said second lens unit during focusing.

25 7. The lens system according to Claim 5, which satisfies the following conditions:

$$0.7 < f_1/f < 1.3, \text{ and}$$

$$1.5 < f_2/f < 2.5,$$

where f_1 is a focal length of said first lens unit, f_2 a focal length of said second lens unit, and f a focal length of the entire lens system.

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8. The lens system according to Claim 5, wherein said diffractive surface consists of a diffraction grating rotationally symmetric with respect to the optical axis,

10 wherein when the phase $\phi(h)$ of said diffraction grating is given by the following equation:

$$\phi(h) = 2\pi/\lambda \cdot (C_1 \cdot h^2 + C_2 \cdot h^4 + C_3 \cdot h^6 + \dots + C_i \cdot h^{2i}),$$

15 where λ is an arbitrary wavelength in the visible region, C_i aspheric phase coefficients, and h a height from the optical axis,

the following conditions are satisfied:

$$C_1 < 0 \text{ and } C_2 > 0.$$

20 9. The lens system according to Claim 5, which satisfies the following condition:

$$|\Delta s_1/f| > 1.0,$$

25 where Δs_1 is a maximum moving length of said first lens unit during focusing from an object at infinity to an object at a near distance, and f a focal length of the entire lens system.

10. A lens system comprising;

a diffractive surface, and

a first lens unit of a positive refracting power,
a second lens unit of a positive refracting power, and
a lens unit of a negative refracting power closest to
5 an image, in the order (named) from the object side,
wherein during focusing from an object at infinity
to an object at a near distance said first lens unit
and said second lens unit move toward the object side
and an air space increases on the said object side from
10 said lens unit of the negative refracting power.

11. The lens system according to Claim 10, which
satisfies the following condition:

$$0.7 < |\Delta s_1 / \Delta s_2| < 1.3,$$

15 where Δs_1 is a moving distance of said first lens
unit during focusing and Δs_2 a moving distance of said
second lens unit during focusing.

12. The lens system according to Claim 10, which
20 satisfies the following conditions:

$$0.6 < f_1/f < 1.1,$$

$$1.5 < f_2/f < 3.5, \text{ and}$$

$$-6.0 < f_R/f < -2.0,$$

where f_1 is a focal length of said first lens
25 unit, f_2 a focal length of said second lens unit, f_R a
focal length of said lens unit of the negative
refracting power, and f a focal length of the entire

lens system.

13. The lens system according to Claim 10,
wherein said diffractive surface consists of a
5 diffraction grating rotationally symmetric with respect
to the optical axis,

wherein when the phase $\phi(h)$ of said diffraction
grating is given by the following equation:

$$\phi(h) = 2\pi/\lambda*(C1*h^2 + C2*h^4 + C3*h^6 + \dots + Ci*h^{2i}),$$

10 where λ is an arbitrary wavelength in the visible
region, Ci aspheric phase coefficients, and h a height
from the optical axis,

the following conditions are satisfied:

$$C1 < 0 \text{ and } C2 > 0.$$

15 14. The lens system according to Claim 10,
wherein said first lens unit or second lens unit
comprises a diffractive surface.

20 15. The lens system according to Claim 10,
wherein said first lens unit and second lens unit
comprise their respective, diffractive surfaces.

25 16. The lens system according to Claim 10,
wherein said lens unit of the negative refracting power
is fixed during the focusing.

17. The lens system according to Claim 10, which satisfies the following condition:

$$|\Delta s_1/f| > 1.0,$$

where Δs_1 is a moving distance of the first lens unit during said focusing and f a focal length of the entire lens system.

18. A lens system comprising;

a diffractive surface, and

a first lens unit of a positive refracting power and a second lens unit of a negative refracting power in the order (named) from the object side,

wherein during focusing from an object at infinity to an object at a near distance, said first lens unit moves toward said object side and a spacing increases between said first lens unit and said second lens unit.

19. The lens system according to Claim 18, which satisfies the following conditions:

$$0.5 < f_1/f < 1.1, \text{ and}$$

$$-2.5 < f_2/f < -1.5,$$

where f_1 is a focal length of said first lens unit, f_2 a focal length of said second lens unit, and f a focal length of the entire lens system.

20. The lens system according to Claim 18, wherein said first lens unit comprises a diffractive

surface.

21. The lens system according to Claim 18,
wherein said diffractive surface consists of a
5 diffraction grating rotationally symmetric with respect
to the optical axis,

wherein when the phase $\phi(h)$ of said diffraction
grating is given by the following equation:

$$\phi(h) = 2\pi/\lambda*(C1*h^2 + C2*h^4 + C3*h^6 + \dots + Ci*h^{2i}),$$

10 where λ is an arbitrary wavelength in the visible
region, Ci aspheric phase coefficients, and h a height
from the optical axis,

the following conditions are satisfied:

$$C1 < 0 \text{ and } C2 > 0.$$

15 22. The lens system according to Claim 18,
wherein said second lens unit is fixed during the
focusing.

20 23. A lens system comprising;
a diffractive surface, and
a first lens unit of a positive refracting power
and a second lens unit of a positive refracting power
in the order (named) from the object side,
25 wherein during focusing from an object at infinity
to an object at a near distance, said first lens unit
moves toward the object side.

24. The lens system according to Claim 23, which satisfies the following conditions:

$$0.7 < f_1/f < 1.3, \text{ and}$$

$$f_2/f > 10,$$

5 where f_1 is a focal length of said first lens unit, f_2 a focal length of said second lens unit, and f a focal length of the entire lens system.

25. The lens system according to Claim 23,
10 wherein said first lens unit comprises said diffractive surface.

26. The lens system according to Claim 23,
wherein said diffractive surface consists of a
15 diffraction grating rotationally symmetric with respect to the optical axis,

wherein when the phase $\phi(h)$ of said diffraction grating is given by the following equation:

$$\phi(h) = 2\pi/\lambda \cdot (C_1 \cdot h^2 + C_2 \cdot h^4 + C_3 \cdot h^6 + \dots + C_i \cdot h^{2i}),$$

20 where λ is an arbitrary wavelength in the visible region, C_i aspheric phase coefficients, and h a height from the optical axis,

the following conditions are satisfied:

$$C_1 < 0 \text{ and } C_2 > 0.$$

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27. The lens system according to Claim 23,
wherein said second lens unit is fixed during the

focusing.

28. A lens system comprising;

a diffractive surface, and

5 a first lens unit of a positive refracting power,
a second lens unit of a negative refracting power, and
a third lens unit of a positive refracting power in the
order (named) from the object side,

10 wherein during focusing from an object at infinity
to an object at a near distance, said first lens unit
is fixed, said second lens unit moves toward an image
side, and said third lens unit moves toward the object
side.

15 29. The lens system according to Claim 28, which
satisfies the following condition:

$$0.50 < \Delta s_2 / |\Delta s_3| < 1.50,$$

20 where Δs_2 is a moving distance of said second lens
unit during the focusing and Δs_3 a moving distance of
said third lens unit during the focusing.

30. The lens system according to Claim 28, which
satisfies the following conditions:

$$0.40 < f_1/f < 0.65,$$

25 $-0.50 < f_2/f < -0.25$, and

$$0.40 < f_3/f < 1.10,$$

where f_1 is a focal length of said first lens

unit, f_2 a focal length of said second lens unit, f_3 a focal length of said third lens unit, and f a focal length of the entire lens system.

5 31. The lens system according to Claim 28, wherein said diffractive surface consists of a diffraction grating rotationally symmetric with respect to the optical axis,

 wherein when the phase $\phi(h)$ of said diffraction
10 grating is given by the following equation:

$$\phi(h) = 2\pi/\lambda*(C_1*h^2 + C_2*h^4 + C_3*h^6 + \dots + C_i*h^{2i}),$$

 where λ is an arbitrary wavelength in the visible region, C_i aspheric phase coefficients, and h a height from the optical axis,

15 the following conditions are satisfied:

$$C_1 < 0 \text{ and } C_2 > 0.$$

 32. The lens system according to Claim 28, wherein said first lens unit comprises a positive lens
20 closest to the object.

 33. The lens system according to Claim 28, wherein a stop is placed between said second lens unit and said third lens unit and said stop is fixed during
25 the focusing.

 34. The lens system according to Claim 28, which

comprises a flare cut stop in the optical path.

35. The lens system according to Claim 28,
wherein said second lens unit and said third lens unit
5 both comprise their respective cemented lenses.

36. A lens system comprising;
a diffractive surface, and
a first lens unit of a positive refracting power,
10 a second lens unit of a negative refracting power, a
third lens unit of a positive refracting power, and a
fourth lens unit of a negative refracting power in the
order (named) from the object side,
wherein during focusing from an object at infinity
15 to an object at a near distance, the first lens unit is
fixed, said second lens unit moves toward an image
side, and said third lens unit moves toward the object
side.

20 37. The lens system according to Claim 36, which
satisfies the following condition:

$$0.50 < \Delta s_2 / |\Delta s_3| < 1.50,$$

where Δs_2 is a moving distance of said second lens
unit during the focusing and Δs_3 a moving distance of
25 said third lens unit during the focusing.

38. The lens system according to Claim 36, which

satisfies the following conditions:

$$0.40 < f1/f < 0.70,$$

$$-0.45 < f2/f < -0.25,$$

$$0.25 < f3/f < 0.55, \text{ and}$$

5 $-1.0 < f4/f < -0.4,$

where f1 is a focal length of said first lens unit, f2 a focal length of said second lens unit, f3 a focal length of said third lens unit, f4 a focal length of said fourth lens unit, and f a focal length of the entire lens system.

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39. The lens system according to Claim 36, wherein said first lens unit comprises a positive lens closest to the object.

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40. The lens system according to Claim 36, wherein a stop is placed between said second lens unit and said third lens unit and said stop is fixed during the focusing.

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41. The lens system according to Claim 36, which comprises a flare cut stop in the optical path.

42. The lens system according to Claim 36, wherein said second lens unit and said third lens unit both comprise their respective cemented lenses.

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43. The lens system according to Claim 36,
wherein said diffractive surface consists of a
diffraction grating rotationally symmetric with respect
to the optical axis,

5 wherein when the phase $\phi(h)$ of said diffraction
grating is given by the following equation:

$$\phi(h) = 2\pi/\lambda*(C1*h^2 + C2*h^4 + C3*h^6 + \dots + Ci*h^{2i}),$$

10 where λ is an arbitrary wavelength in the visible
region, Ci aspheric phase coefficients, and h a height
from the optical axis,

the following conditions are satisfied:

$$C1 < 0 \text{ and } C2 > 0.$$

15 44. A lens system comprising;
a diffractive surface, and
a first lens unit of a positive refracting power,
a second lens unit of a negative refracting power, a
third lens unit of a positive refracting power, and a
fourth lens unit of a positive refracting power in the
20 order (named) from the object side,

wherein during focusing from an object at infinity
to an object at a near distance, the first lens unit is
fixed, said second lens unit moves toward an image
side, and said third lens unit moves toward the object
25 side.

45. The lens system according to Claim 44, which

satisfies the following condition:

$$0.50 < \Delta s_2 / |\Delta s_3| < 4.00,$$

where Δs_2 is a moving distance of said second lens unit during the focusing and Δs_3 a moving distance of said third lens unit during the focusing.

46. The lens system according to Claim 44, which satisfies the following conditions:

$$0.20 < f_1/f < 0.60,$$

$$-0.50 < f_2/f < -0.10,$$

$$0.50 < f_3/f < 1.50, \text{ and}$$

$$0.70 < f_4/f < 1.80,$$

where f_1 is a focal length of said first lens unit, f_2 a focal length of said second lens unit, f_3 a focal length of said third lens unit, f_4 a focal length of said fourth lens unit, and f a focal length of the entire lens system.

47. The lens system according to Claim 44, wherein said diffractive surface consists of a diffraction grating rotationally symmetric with respect to the optical axis,

wherein when the phase $\phi(h)$ of said diffraction grating is given by the following equation:

$$\phi(h) = 2\pi/\lambda * (C_1 * h^2 + C_2 * h^4 + C_3 * h^6 + \dots + C_i * h^{2i}),$$

where λ is an arbitrary wavelength in the visible region, C_i aspheric phase coefficients, and h a height

from the optical axis,

the following conditions are satisfied:

$C1 < 0$ and $C2 > 0$.

5 48. The lens system according to Claim 44,
wherein during the focusing, said fourth lens unit is
fixed relative to the image plane.

10 49. The lens system according to Claim 44, which
comprises a stop in the optical path, wherein said stop
is fixed during the focusing.

15 50. The lens system according to Claim 44, which
comprises a flare cut stop in the optical path.

51. An optical device comprising;
the lens system of Claim 1, and
a housing which holds said lens system.

20 52. An optical device comprising;
the lens system of Claim 5, and
a housing which holds said lens system.

25 53. An optical device comprising;
the lens system of Claim 10, and
a housing which holds said lens system.

54. An optical device comprising;
the lens system of Claim 18, and
a housing which holds said lens system.

5 55. An optical device comprising;
the lens system of Claim 23, and
a housing which holds said lens system.

10 56. An optical device comprising;
the lens system of Claim 28, and
a housing which holds said lens system.

15 57. An optical device comprising;
the lens system of Claim 36, and
a housing which holds said lens system.

58. An optical device comprising;
the lens system of Claim 44, and
a housing which holds said lens system.